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Interactive comment on "Theoretical uncertainties for global satellite-derived burned area estimates" *by* James Brennan et al.

Anonymous Referee #2

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General Comments:

Brennen et al. present an estimate of the uncertainties of global burned area estimates for three products for the period spanning January 2001 to December 2013. The uncertainty estimates are based on the triple collocation (TC) analysis model which has been used in other fields including wind speed and soil moisture estimation. Results from this study could be useful to the modelling community. The structure of the paper suits the research well, and the manuscript nicely summarizes the state of burned area products and the methods used for creating the products in question (MCD64A1 C6, MCD45A1 C5.1, FireCCI50). However, the authors have missed some of the recent advances in product validation and generation which might make this manuscript out of date already.

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Discussion paper

Beginning with the product selection, two of the products (MCD45A1 C5.1 and FireCCI50) have been replaced at this point – the former by the MODIS Collection 6 MCD64A1 product and the latter by FireCCI51 (https://geogra.uah.es/fire_cci/). As such, the use of a deprecated product such as MCD45A1 C5.1 seems odd assuming that the Collection 6 implementation should be an improvement over the outgoing product. Recognizing that the triple collocation method requires a third dataset, a current operational product such as the Copernicus Burnt Area (https://land.copernicus.eu/global/products/ba) could have been implemented.

Broadly, there should be a discussion of the influence of data set selection on the results of the uncertainty indicators. Several factors are of concern in this regard: – The accuracy of burned area products are generally "low," where omission errors ranging from 60% to 80% and commission errors range from 30% to 60% for three global products which included FireCCI50 and MCD64A1 C6 (according to Chuvieco et al., 2018). How does the accuracy influence the result of the TC analysis, given that the accuracy of the products is unknown for the purposes of this study? Should the reader interpret the results as being specific to these 3 products? – Considering the high rate of omission errors, is it not likely that the requirement that all three products identify burning in a cell is overly restrictive? What if one is wrong and two are not? It would be helpful to know how many of the 40% of cells (Page 7 Line 13) had burned area identified by at least one product. – Related to the previous point, a value of 0 burned area can be a correct classification. Is it valid to throw out the value 0 simply because of the log transformation? It is not a "no data" value. – Roteta et al. (2019) claim that burned area estimates in Africa are more than 80% higher when using 20m Sentinel-2 data compared to MCD64A1. Their result is incompatible with the results of this work, so there needs to be a more nuanced explanation of what uncertainty is in the context of this study given that comparison of two products at 250m resolution is not the same as one product at 250m and another at 20m.

A more important issue is the recent advances in burned area product validation which were not accounted for in this manuscript. For example, in P2 L9-11, the (uncited) claim is made that "Even the largest and most sophisticated validation datasets correspond to only a small sampling of global fire activity, and it is not clear whether this is sufficient information to build an understanding of uncertainties at global and decadal scales". The work done by Boschetti et al., 2016; Padilla et al., 2015; and Padilla et al., 2017 show that uncertainty can, in fact, be identified at the global scale using stratified random sampling. On P1 L17, it is stated (again uncited) that the "true information content of such datasets is still unquantified," yet the uncertainties of the FireCCI50 and MCD64A1 products are provided as part of the accuracy assessment done by Chuvieco et al. (2018) as well as within the FireCCI50 gridded product itself (P4 L15). The references to other works which call for the availability of uncertainty data (e.g. Mouillot et al., 2014; Rabin et al., 2017; Yue et al., 2014; Knorr et al., 2014) pre-date the work which has been done through more current validation exercises such as that in Chuvieco et al. (2018) and Roteta et al. (2019).

Finally, the manuscript needs more context to explain why this work is necessary, especially given that there are Stage 3 burned area validation datasets which can provide estimates of uncertainty in the burned area measurements. The CEOS LPV guidelines for validation stages are referenced in the Discussion, and while the validation stage definitions are somewhat vague for stage 3 (https://lpvs.gsfc.nasa.gov/), "uncertainty" has typically been understood to refer to accuracy with an associated uncertainty accompanying the accuracy estimate. While the TC method in this manuscript can provide uncertainty estimates, perhaps even compatible with Stage 4, the uncertainty is presented independent of the accuracy of the data set – a user cannot use the uncertainty information alone to know how likely a given pixel is to be correctly labeled. This is of less concern to the modelling community, but should be addressed nonetheless.

Specific Comments:

– The abstract needs to be rewritten. The first sentence ends with a dangling participle ("these datasets" refers to nothing); the study period should be included in the abstract; the sentence about the uncertainty estimates is unclear – at minimum it should note that the estimates are per year, but the phrase "Theoretical uncertainties indicate constraints. . ." is unnecessarily complicated given that the values are simply burned area estimates with uncertainty; "product" should be "products"; why are Africa and Australia singled out in the abstract?

– A definition of uncertainty should be provided to distinguish between uncertainty in total burned area vs (for example) temporal uncertainty in day of burning. This is also important in light of the findings of Roteta et al. (2019) whose results are incompatible with these using the conventional understanding of uncertainty.

– P2 L7 "validation exercises": Some of the previously referenced studies are intercomparisons, not validation exercises - the former does not imply accuracy assessment. For example, in Humber et al. (2018), no assumption is made that any one product is correct and in fact it is possible that all four products are incorrect for any given burn.

– P3 L22-23 "Simon et al. [. . .]": This does not need to be included, all algorithms have parameters which lead to commission/omission errors.

– P7: How is the aggregation affected by temporal uncertainty, such as that indicated by the MCD64A1 SDS or the nominal 8-day uncertainty of the MCD45A1 product? In theory even a 1-day shift in burn date detection could lead a cell to be excluded erroneously from a 16-day period and the temporal uncertainty of MCD45A1 is in fact greater than half of the compositing period. Generally, given that this is a paper about uncertainty, it would be good to incorporate the temporal uncertainty in the measurements somehow.

– P8: Generally, it would benefit the reader to have a discussion of the fire seasonality – the calendar year has been shown to be a fairly bad cutoff period for burned area. In Figure 3, the reader would benefit from knowing that the peaks in uncertainty correspond to the peak of the burning season in Australia. The legend for the figure should also indicate that this figure refers to Australia, and the figure on the right is missing the x-axis labels.

– P12 L8: The problem with the definition of uncertainty is very evident here ("[. . .] cropland burning with relative uncertainties of 8-10%.") The products generally agree with each other about cropland burning, however they are all severely underestimating the total amount (See Hall et al., 2016 which demonstrated MCD45A1 and MCD64A1 underestimate agricultural burning by > 90%). This illustrates that the uncertainty presented here is relative to the other products, underscoring the need for ground data as a baseline for comparison.

– P13: The comparison the MCD64A1 C5.1 might not be relevant, many things about the product were changed and there is not a flat 26% increase in burned area globally – some regions increased significantly more than others, and the detection rate of small fires is significantly higher in the Collection 6 product. Perhaps a better test of the TC method would be to replace the Collection 6 product with Collection 5.1 for the purpose of comparing the result.

– P19 L5-7 "the majority of current burned area products have only achieved stage two validation": What are the current burned area products referred to in this sentence? Of publicly available operational (global) products, three come to mind (FireCCI51, MCD64A1, Copernicus Burnt Area), and of those two were validated at Stage 3 in Chuvieco et al. (2018). The reference to Padilla et al. (2014) is actually a strategy for Stage 3 validation (not Stage 2), and the reference should be expanded to include Boschetti et al. (2016) and Padilla et al. (2017), both of which improve upon the temporal robustness of the sample necessary to provide accuracy and uncertainty estimates through time.

– P20 L17-18: It seems the results are relevant to modelers at coarse resolutions. How would a user implement this work at finer scales?

– P21: How should a user implement the information from this work? What about reconciling the differences with works like Roteta, who indicated burned area totals in

Africa are well outside of the bounds of uncertainty presented in this work?

Technical Comments:

– P5 L30: Should refer to eq. 2-4. – P6 Figure 1: Typo in legend of figure on the left. – P7 L1: Specify 1 degree at the equator. – P11 L5: “product’s” should be “products” – P13 L32-33: The last sentence is a fragment. – P19 L4: The reference to Giglio et al., 2006b should be with “GFED4” – P19 L17: Remove parenthesis around Zhu et al. – P20 L16-17: References should be in parenthesis.

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